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Multipole and phase tuning methods for insertion devices

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Multipole and phase tuning of insertion devices is important for maintaining beam dynamics and reaching the high brilliance goals of the APS. STI has used enhanced multipole and phase tuning techniques on the first ten insertion devices shipped to the APS. Several general approaches will be described: magnet sorting, mechanical adjustments, and end-pole shaping and shimming. Surface field magnet measurements are used for initial magnet sorts. Off-axis Hall probe measurements after assembly guide magnet swaps and local mechanical adjustments. A recent development has been end pole shaping guided by potential theory. Shimming of wigglers and undulators has been used successfully for many years to enhance their magnetic performance. STI's phase shimming techniques were originally developed in 1989 and applied to a 10-meter-long Free Electron Laser undulator without affecting multipoles or steering. The wide gap tuning range of the APS devices requires careful matching of device errors and correction gap dependencies in the $g/l = 0.18$ to 0.6 range. Shims are especially gap sensitive at small g/l . We will describe signatures, gap dependencies, algorithms, modelling, and experimental results for these techniques.